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PREASSESSMENT SCREEN:

Clark Fork River Basin NPL Sites, Montana

State of Montana
Natural Resource Damage Assessment Program

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EXECUTIVE SUMMARY

The State of Montana has commenced an action against the Atlantic Richfield Company ("ARCO") in the United States District Court for the District of Montana pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act ("CERCLA"), and the Montana Comprehensive Environmental Cleanup and Responsibility Act ("CECRA"). The lawsuit seeks the recovery of damages for injuries to natural resources resulting from releases of hazardous and/or deleterious substances from facilities for which ARCO is the responsible party. The State of Montana has begun to assess the natural resource damages in accordance with the regulations of the U.S. Department of the Interior.

The purpose of the Preassessment Screen is to determine whether a discharge or release of hazardous substances warrants conducting a full-scale Natural Resource Damage Assessment. It is intended by the Department of the Interior to be a "rapid review of readily available information...to ensure that there is a reasonable probability of making a successful claim" and, therefore, to determine whether a damage assessment should be performed. This determination depends on whether it can be reasonably established (with data that can be obtained in the future, or that are already available) that:

1. A release of a hazardous substance has occurred;
2. Natural resources for which the State of Montana can assert trusteeship have been, or are likely to be, adversely impacted by the release;
3. The quantity and concentration of the released substances are sufficient to potentially cause injury to those natural resources;
4. Data sufficient to pursue an assessment are readily available or likely to be obtained at reasonable cost; and
5. Response actions carried out or planned pursuant to the Superfund RI/FS program will not sufficiently remedy the injury to natural resources without further action.

It should be emphasized that this Preassessment Screen presents data sufficient to support the above criteria based on information readily available to the State, rather than a summary of all existing data.

In this Preassessment Screen, the State of Montana finds that ARCO is responsible for multiple and at times continuous releases of hazardous substances into the Clark Fork River Basin and vicinity. Hazardous substances released include arsenic, beryllium, cadmium, copper, creosote, lead, mercury, pentachlorophenol, polycyclic aromatic hydrocarbons (PAH), selenium, silver, volatile organic compounds, and zinc. The releases of the hazardous substances from the four National Priority List (NPL) sites (Silver Bow

Creek/Butte Area, Montana Pole, Anaconda Smelter, and Milltown Reservoir/Clark Fork River), have been in sufficient quantity, concentration, and duration to have injured the natural resources of the Clark Fork River Basin and surrounding areas. Natural resources potentially injured by the releases of hazardous substances include surface water, groundwater, soils, sediments, vegetation (including wetlands and upland vegetation), fish and other aquatic biota, wildlife, and air.

Following release of this Preassessment Screen and submission of a Notice of Intent to perform an assessment, the State of Montana intends to publish its Assessment Plan for public comment. Following the public comment period, the State will perform its Natural Resource Damage Assessment. Following completion of the assessment, an Assessment Report will be published.

TABLE OF CONTENTS

EXECUTIVE SUMMARY . . . . *i*

LIST OF TABLES . . . . *v*

LIST OF FIGURES . . . . *vi*

LIST OF ACRONYMS . . . . *vii*

1.0 INTRODUCTION 1

- 1.1 INTENT OF THE PREASSESSMENT SCREEN 1
- 1.2 CRITERIA TO BE ADDRESSED BY THE PREASSESSMENT PHASE 2

2.0 PREASSESSMENT SCREEN -- INFORMATION ON THE SITE (§11.24) 3

- 2.1 HISTORY OF MINING IN THE CLARK FORK BASIN 3
- 2.2 LOCATION AND DESCRIPTION OF CLARK FORK BASIN 4
- 2.3 TIME, QUANTITY, DURATION, AND FREQUENCY OF RELEASES OF HAZARDOUS SUBSTANCES 4
  - 2.3.1 Silver Bow Creek/Butte Area Site 4
  - 2.3.2 Anaconda Smelter Site 8
  - 2.3.3 Montana Pole Site 8
  - 2.3.4 Milltown Reservoir Site 10
- 2.4 HAZARDOUS SUBSTANCES RELEASED 13
- 2.5 ADDITIONAL HAZARDOUS SUBSTANCES POTENTIALLY RELEASED FROM THE SITES 13
- 2.6 RELEVANT OPERATIONS OCCURRING AT OR NEAR THE SITES 13
- 2.7 POTENTIALLY RESPONSIBLE PARTIES 14
- 2.8 DAMAGES EXCLUDED FROM LIABILITY 14

TABLE OF CONTENTS

3.0 PREASSESSMENT SCREEN -- PRELIMINARY IDENTIFICATION OF RESOURCES AT RISK (§11.25) 15

3.1 PATHWAY IDENTIFICATION 15
3.2 EXPOSED AREAS 16
3.2.1 Primary Depositional Areas 16
3.2.2 Areas Exposed through Pathways 17
3.2.3 Areas of Indirect Effect 18
3.3 ESTIMATES OF CONCENTRATIONS 18
3.3.1 Silver Bow Creek/Butte Area Sites 27
3.3.2 Anaconda Sites 27
3.3.3 Milltown Sites 28
3.3.4 Montana Pole Site 29
3.3.5 Biological Samples 29
3.4 POTENTIALLY AFFECTED RESOURCES 32
3.5 PRELIMINARY ESTIMATE OF AFFECTED SERVICES 32

4.0 PREASSESSMENT SCREEN -- DETERMINATION CRITERIA (§11.23(e)) . 34

4.1 A RELEASE OF HAZARDOUS SUBSTANCES HAS OCCURRED . . 34
4.2 NATURAL RESOURCES FOR WHICH THE STATE OF MONTANA IS TRUSTEE HAVE BEEN ADVERSELY AFFECTED BY THE RELEASE 34
4.3 THE QUANTITY AND CONCENTRATION OF THE RELEASED HAZARDOUS SUBSTANCES ARE SUFFICIENT TO CAUSE INJURY 34
4.3.1 Surface Water 34
4.3.2 Groundwater 35
4.3.3 Aquatic Organisms 36
4.3.4 Wildlife 37
4.3.5 Vegetation and Soils 37
4.4 DATA SUFFICIENT TO PURSUE AN ASSESSMENT ARE AVAILABLE OR LIKELY TO BE OBTAINED AT REASONABLE COST 40
4.5 RESPONSE ACTIONS WILL NOT SUFFICIENTLY REMEDY THE INJURY TO NATURAL RESOURCES WITHOUT FURTHER ACTION 41

5.0 LITERATURE CITED 42

LIST OF TABLES

Table 1. National Priority List (NPL) Sites and Operable Units in Clark Fork Basin (U.S. EPA and MDHES 1990) 6

Table 2. Representative Surficial Concentrations of Hazardous Substances at Clark Fork NPL Sites 19

Table 3. Representative Concentrations of Hazardous Substances in Groundwater at Clark Fork NPL Sites 24

Table 4. Water Quality Parameters of Four Heavy Metals for the Protection of Freshwater Aquatic Life 26

Table 5. Representative Residues of Hazardous Substances in Clark Fork River Biota 30

Table 6. Examples of Effects of Selected Hazardous Substances Found in the Clark Fork Basin 38

Table 7. Plant Tissue Concentrations Reported for Clark Fork River Basin Vegetation Compared with Grass and Wheat Leaf Concentrations Known to Have Produced a 10% Biomass Decrease. 39

LIST OF FIGURES

Figure 1. Location of Superfund Sites in the Clark Fork River Basin (U.S. EPA MDHES 1990). 5

Figure 2. Silver Bow Creek/Butte Area and Montana Pole NPL Sites (U.S. EPA MDHES 1990). 7

Figure 3. Anaconda Superfund Site Operable Unit Locations (U.S. EPA and MDHES 1990). 9

Figure 4. Clark Fork River Operable Unit: Milltown Reservoir Site (U.S. EPA and MDHES 1990). 11

Figure 5. Milltown Reservoir Site (U.S. EPA and MDHES 1990). 12

LIST OF ACRONYMS

ACMC	Anaconda Copper Mining Company
ARCO	Atlantic Richfield Company
CECRA	Comprehensive Environmental Cleanup and Responsibility Act
CERCLA ("Superfund")	Comprehensive Environmental Response, Compensation, and Liability Act
DHES	see MDHES
GIS	Geographic Information System
MDHES	Montana Department of Health and Environmental Sciences
MPTP	Montana Pole and Treatment Plant
MR	Montana Resources
NPL	National Priority List
NRDA	Natural Resource Damage Assessment
PAH	Polycyclic Aromatic Hydrocarbon
PCP	Pentachlorophenol
ppb	parts per billion
ppm	parts per million
PRP	Potentially Responsible Party
RI/FS	Remedial Investigation/Feasibility Study
U.S. EPA	United States Environmental Protection Agency
USGS	United States Geological Survey

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1.0 INTRODUCTION

The State of Montana has commenced an action against the Atlantic Richfield Company ("ARCO") in the United States District Court for the District of Montana (Civil Action No. CV 83-317-HLN-CCL) pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act ("CERCLA"), 42 U.S.C. §§ 9601-9675, and the Montana Comprehensive Environmental Cleanup and Responsibility Act ("CECRA"), Mont. Code Ann. §§ 75-10-701 to 75-10-724. Generally, the lawsuit seeks the recovery of damages for injuries to natural resources resulting from releases of hazardous and/or deleterious substances from facilities for which ARCO is the responsible party. The State of Montana has begun to assess the natural resource damages in accordance with the regulations of the U.S. Department of the Interior as set forth at 43 C.F.R. Part 11.

Following release of this Preassessment Screen and submission of a Notice of Intent to perform an assessment, the State of Montana intends to publish its Assessment Plan for public comment. Following the public comment period, the State will perform its Natural Resource Damage Assessment. Following completion of the assessment, an Assessment Report will be published.

This preassessment screen was prepared by RCG/Hagler, Bailly, Inc. under contract to the State of Montana.

1.1 INTENT OF THE PREASSESSMENT SCREEN

The purpose of a Preassessment Screen is to determine whether a discharge or release of hazardous substances warrants conducting a full-scale Natural Resource Damage Assessment (NRDA). It is "a rapid review of readily available information...to ensure that there is a reasonable probability of making a successful claim"[1] and, therefore, to determine whether a damage assessment should be performed.

It should be emphasized that the Preassessment Screen presents data sufficient to support the above criteria based on information readily available to the State. It is not a summary of all existing data.

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[1] 43 CFR Section 11.23.

1.2 CRITERIA TO BE ADDRESSED BY THE PREASSESSMENT PHASE

In 43 CFR Part 11, Subpart B defines the content of the Preassessment Phase of a NRDA. These regulations[2] establish criteria by which the decision to proceed past the preassessment phase to a full assessment must be based. These criteria are:

1. A release of a hazardous substance has occurred;
2. Natural resources for which the State of Montana can assert trusteeship have been, or are likely to be, adversely impacted by the release;
3. The quantity and concentration of the released substances are sufficient to potentially cause injury to those natural resources;
4. Data sufficient to pursue an assessment are readily available or likely to be obtained at reasonable cost; and
5. Response actions carried out or planned pursuant to the Superfund RI/FS program will not sufficiently remedy the injury to natural resources without further action.

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[2] 42 CFR Section 11.23(e).

2.0 PREASSESSMENT SCREEN -- INFORMATION ON THE SITE (§11.24)

2.1 HISTORY OF MINING IN THE CLARK FORK BASIN

When Meriwether Lewis and William Clark explored the region that is now Montana, they described the area near the Clark Fork River as a "unique landscape of primitive beauty" (Lang 1988). Several decades later, miners began extracting the vast mineral resources of the area. In 1882, the great copper body of Butte was discovered; by 1884 Butte Hill supported 10 large-scale copper mines, 4,000 posted claims, and eight operating smelters (Camp Dresser & McKee 1990a). In 1895, the Anaconda Copper Mining Company (ACMC) was incorporated; over the course of the ensuing ten years, ACMC gained control over most of the independent operations in the Butte area. By 1896 over 4,500 tonnes (4,960 tons) of ore were processed per day, and by 1899 Butte was producing 41% of domestic copper and 25% of the world's copper, and contained 42 working smelters (Freeman 1900).

In 1902, the Washoe Reduction Works and Smelter were constructed in Anaconda, 25 miles (40 km) northwest of Butte. By the early 1900s, the Washoe Smelter was processing 11,500 tonnes (12,700 tons) of ore per day. The early 1950s saw the start of the enormous Berkeley Pit in Butte. In 1976, the Atlantic Richfield Company (ARCO) purchased ACMC. In 1980, the Anaconda smelter was shut down as a result of a drop in copper prices. When the smelter at Anaconda stopped production, over 1 billion tonnes (1.1 billion tons) of ore and waste rock had been produced from the Butte district. In 1981, underground mining was suspended; in 1983, mining in the open pit was stopped and in 1986 the Anaconda Reduction Works was demolished.

Today, the only large mining operation in the Butte area and the upper Clark Fork Basin belongs to Montana Resources (MR). MR mines copper and molybdenum from the Continental Pit in Butte (Johnson and Schmidt 1988).

The mining and smelting operations produced by the "richest hill on earth" (Butte) left behind massive deposits of waste covering an area approximately 1/5 the size of the state of Rhode Island (Moore and Luoma 1990). The complex of wastes which now lies in the Clark Fork River Basin comprises four National Priority List (NPL) sites with numerous operable units. It includes, but is not limited to, approximately 20 square miles (52 km^2) of tailings ponds, more than 175 square miles (453 km^2) of soils and vegetation contaminated by air pollution from smelting operations, at least 30 square miles (78 km^2) of unproductive agricultural land, over 150 miles (242 km) of contaminated river bed and habitat along the Clark Fork River and Silver Bow Creek, and millions of gallons of contaminated groundwater (Johnson and Schmidt 1988; Moore and Luoma 1990).

2.2 LOCATION AND DESCRIPTION OF CLARK FORK BASIN

The Clark Fork River Basin drains an area of over 22,000 square miles (57,000 km^2), including nearly all of Montana west of the Continental Divide, and a small part of northern Idaho. The Clark Fork River and its principal tributaries flow north and west from its headwaters above Butte, Montana for about 340 river miles (547 km) through a variety of terrain, including broad, semi-arid valleys, high mountain ranges, and steep-sided valleys. It terminates at Lake Pend Oreille in northern Idaho, approximately seven miles west of the Montana/Idaho border.

The basin currently contains four NPL sites with numerous operable units (Figure 1 and Table 1). Section 2.3 describes the four NPL sites and provides site-specific breakdowns of the timing, quantity, duration, and frequency of releases of hazardous substances.

2.3 TIME, QUANTITY, DURATION, AND FREQUENCY OF RELEASES OF HAZARDOUS SUBSTANCES

2.3.1 Silver Bow Creek/Butte Area Site

In 1982, the U.S. EPA placed Silver Bow Creek on the Superfund National Priority List. In 1987, the Butte Area was added to the Silver Bow Creek site. The site begins upstream of the Metro Storm Drain in Butte and follows the course of Silver Bow Creek to the Warm Springs Ponds (Figure 2).

Silver Bow Creek originates north of Butte and is a major tributary to the Clark Fork River. Mill tailings and other mining wastes in and near the creek contribute to substantial downstream contamination, particularly by hazardous substances (including arsenic, cadmium, copper, lead, and zinc) which have been released in concentrated forms as by-products of mining and smelting operations (MultiTech 1987a).

Mining in the **Butte Area** began in the mid-1860s when gold was discovered in Baboon Gulch. By the mid-1880s, there were more than 300 operating copper and silver mines and eight smelters (U.S. EPA and MDHES 1990). Early mining operations resulted in large-scale environmental degradation of the region. By the mid-1890s, most of the vegetation in Butte had completely disappeared (Johnson and Schmidt 1988). The result of over 100 years of heavy mining in the area includes waste rock dumps that contain differing quantities of hazardous substances within an estimated 9,850,000 cubic yards (7,535,000 m^3) of metal-contaminated waste (U.S. EPA and MDHES 1990). Secondary releases of hazardous substances from mill tailings and waste rock dumps throughout the Butte Area have contaminated -- and continue to contaminate -- significant amounts of soil, groundwater, and surface water in the Butte Area (U.S. EPA and MDHES 1990).

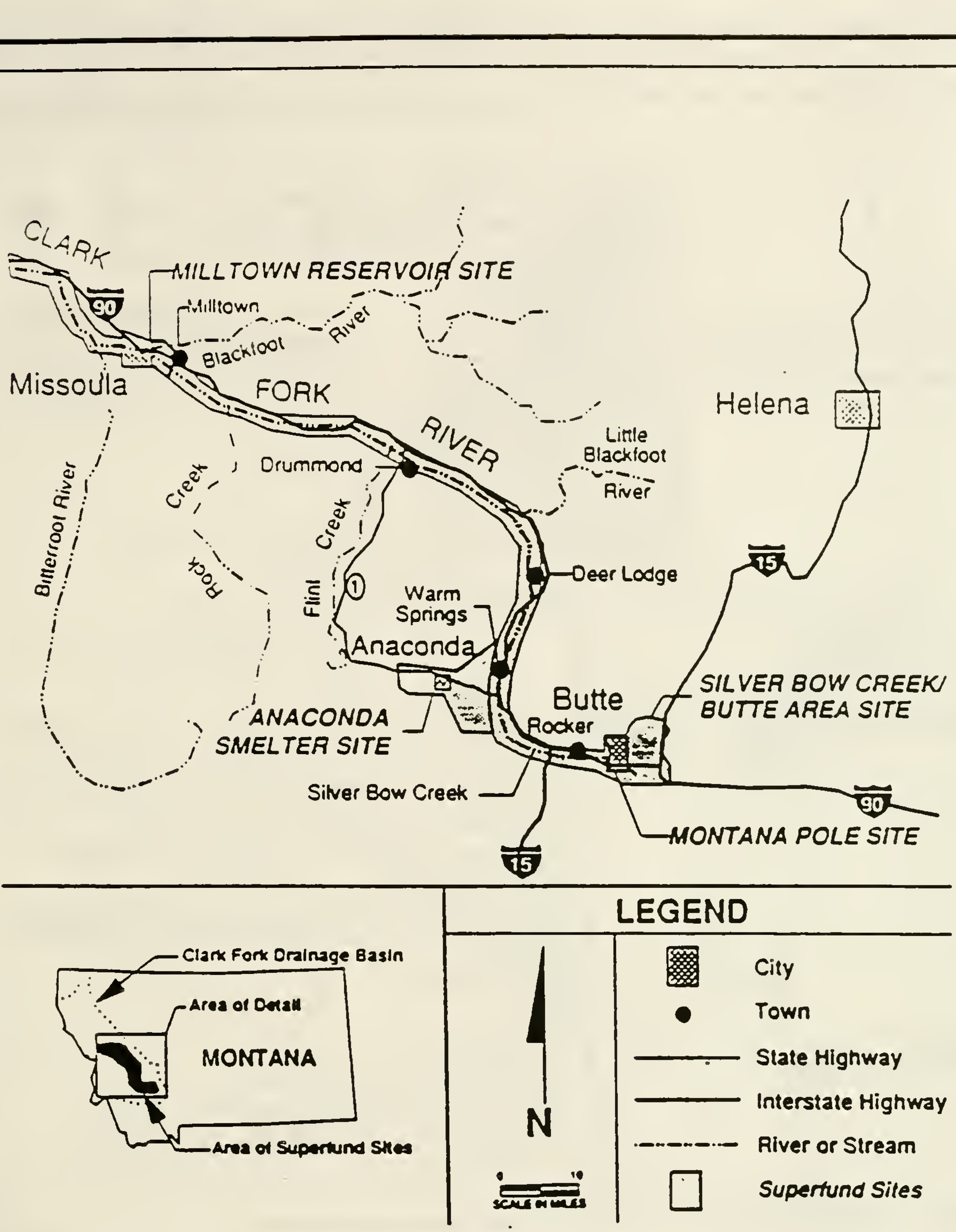

Figure 1. Location of Superfund Sites in the Clark Fork River Basin (U.S. EPA MDHES 1990).

Table 1
National Priority List (NPL) Sites
and Operable Units in Clark Fork Basin
(U.S. EPA and MDHES 1990)

Site	Operable Unit
Silver Bow Creek/Butte Area	Priority Soils Lower Area One Mine Flooding Rocker Warm Springs Ponds Streamside Tailings (Silver Bow Creek) Butte Non-Priority Soils Butte Active Mine Area
Montana Pole	
Anaconda Smelter	Mill Creek Old Works Arbiter Flue Dust Community Soils Smelter Hill Regional Surface Water/Groundwater/Tailings Beryllium Regional Soils Slag
Milltown Reservoir	Milltown Reservoir/Sediments Milltown Water Supply Clark Fork River (Warm Spring Ponds to Missoula)

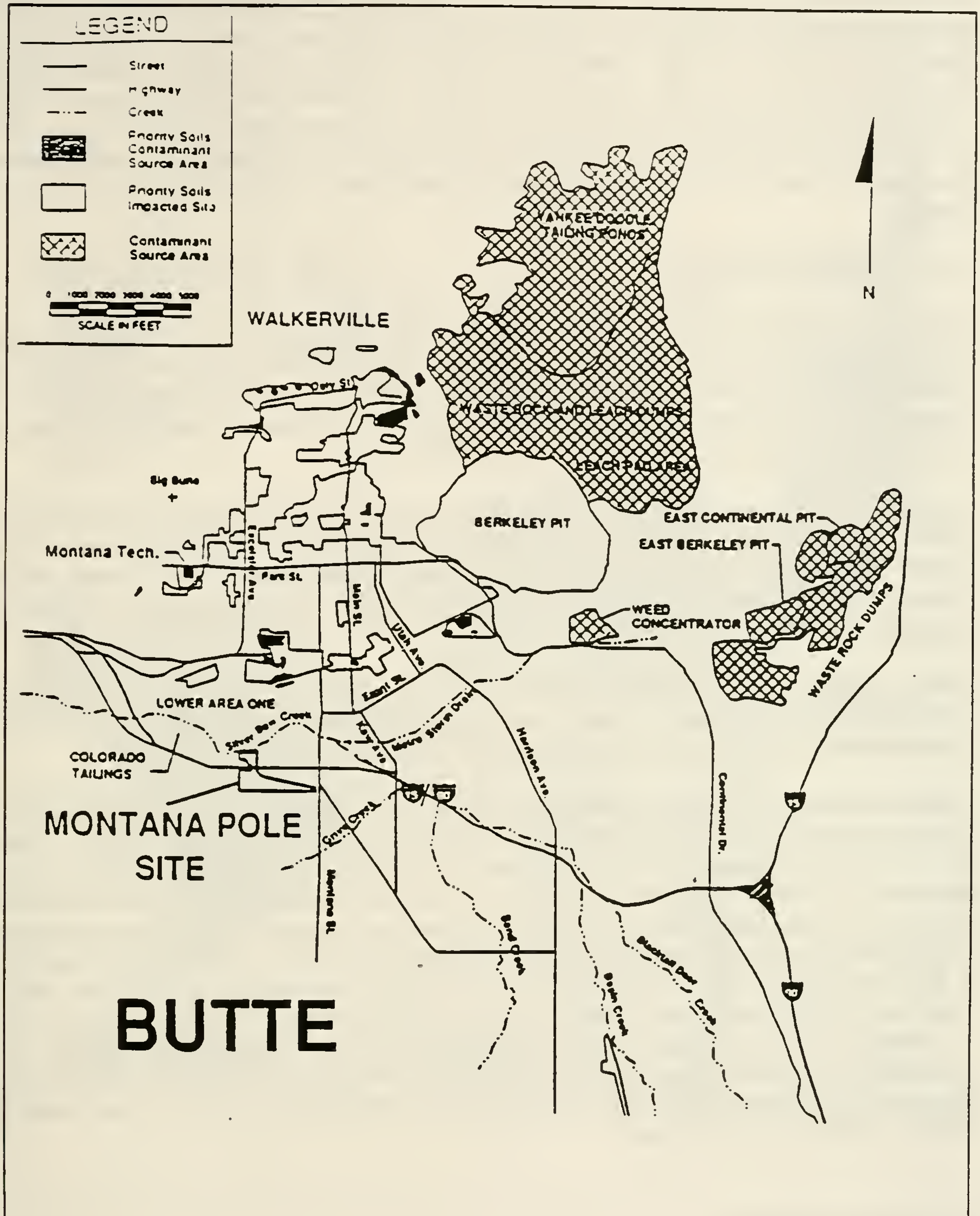

Figure 2. Silver Bow Creek/Butte Area and Montana Pole NPL Sites (U.S. EPA and MDHES 1990).

Multiple, and at times continuous, releases of hazardous substances have occurred at the Silver Bow Creek site from tailings piles (both buried and surface), process waters, contaminated soils, and various point sources through a number of pathways from the 1860s to the present (Multitech 1987a). In addition, repeated, and at times continuous, re-releases of hazardous substances from hydrologic processes (e.g., mobilization of contaminated floodplain sediments from snowmelt or storm runoff) have occurred from the 1860s to the present.

2.3.2 Anaconda Smelter Site

The Anaconda Smelter site is located in and around the city of Anaconda, about 25 miles (40 km) northwest of Butte (Figure 3). Added to the National Priority List in 1983, the site consists of the original smelter ("Old Works") which operated from 1884 to 1902, the Arbiter, Smelter Hill, Anaconda, and Opportunity Tailings Ponds, as well as many square miles of surrounding area (U.S. EPA and MDHES 1990).

Hazardous substances associated with smelter operations are found in the approximately 185 million cubic yards (141.5 million m^3) of tailings, 27 million cubic yards (20.7 million m^3) of furnace slags, and 300,000 cubic yards (229,500 m^3) of flue dusts -- all of which contain elevated concentrations of hazardous substances such as lead, arsenic, cadmium, copper and zinc (U.S. EPA and MDHES 1990).

Tailings typically were deposited in ponds to promote the settling of solids. Multiple and, at times continuous, releases of hazardous substances from these ponds to surface and groundwaters has occurred repeatedly from the 1880s through the present.

Wastes containing arsenic, heavy metals, and other hazardous substances were also released repeatedly from stack emissions while the smelters were in operation (1884-1980). Winds carried these substances over a large part of the Deer Lodge Valley, with eventual deposition of contaminants on the ground (U.S. EPA and MDHES 1990). Aerial deposition from smelter operations and subsequent repeated re-releases of hazardous substances through natural pathways, have led to soil contamination problems throughout a broad area of the valley (U.S. EPA and MDHES 1990). Indeed, soil contamination in the nearby community of Mill Creek was determined by the U.S. EPA to pose unacceptable health risks to residents from continuing arsenic exposures (U.S. EPA and MDHES 1990). An agreement was subsequently reached in 1986 between the U.S. EPA, the Montana Department of Health and Environmental Sciences (MDHES) and ARCO to permanently relocate residents of Mill Creek.

2.3.3 Montana Pole Site

The Montana Pole NPL site, formerly the Montana Pole and Treatment Plant (MPTP), was added to the National Priority List in 1986 as a result of PCP/petroleum contamination present from the treatment of timber products. The Montana Pole site is located along the banks of Silver Bow Creek at 202 W. Greenwood Avenue in Butte, Montana (Figure 2).

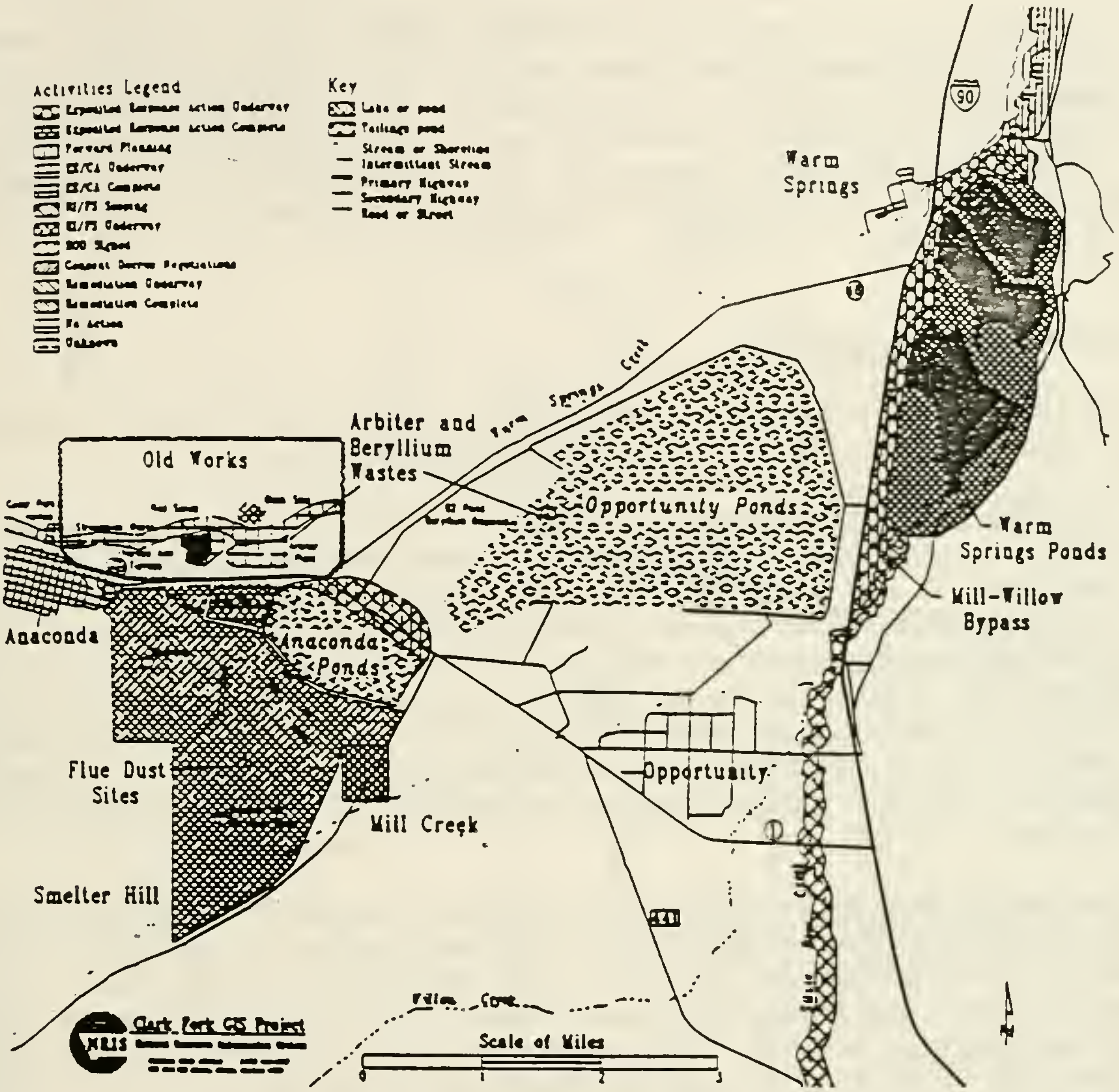

Figure 3. Anaconda Superfund Site Operable Unit Locations (U.S. EPA and MDHES 1990).

Construction of the MPTP began in July 1946; by April 1947, the plant was in full operation (Camp Dresser and McKee 1990a). Between 1947 and 1984, the 40 acre (16.2 ha) site operated nearly continuously, treating timber with a pentachlorophenol (PCP) and petroleum solution. Multiple, and at times continuous, releases of hazardous substances from the site have occurred repeatedly from the 1940s through the present.

In 1983, the U.S. EPA determined that hazardous substances including PCP and creosote were continuously seeping from the site into Silver Bow Creek at a rate of two to five gallons (7.6 to 19 L) per day (U.S. EPA and MDHES 1990). On-site soils, groundwater and surface water were found to be contaminated as well. In 1987, 12,000 cubic yards (9,180 m^3) of contaminated soils were removed and 10,000 gallons (37,900 L) of contaminated groundwater were treated as part of U.S. EPA's Time-Critical Removal process (U.S. EPA and MDHES 1990).

2.3.4 Milltown Reservoir Site

The Milltown Reservoir site includes both the area surrounding the Milltown Reservoir and the upper Clark Fork River from Warm Springs Ponds to Missoula.

The **Clark Fork River** operable unit begins at the Warm Springs Ponds discharge (continuous with the Silver Bow Creek Site) and ends at the Milltown Reservoir -- some 120 river miles (193 km) downstream (Figure 4). Tailings containing various amounts of hazardous substances from Butte and Anaconda have been deposited by river action along the river banks throughout the entire operable unit (U.S. EPA and MDHES 1990). Multiple, and at times continuous, releases of hazardous substances to the river have occurred repeatedly from the 1860s through the present from exposed and buried tailings, bank, bed, and floodplain sediments, the Mill-Willow Bypass, run-off from contaminated lands, and exchange with contaminated groundwater (U.S. EPA and MDHES 1990; Woessner *et al.* 1984).

The **Milltown Reservoir** is located at the confluence of the Clark Fork and the Blackfoot River, adjacent to Milltown (Figure 5). The Milltown Reservoir was constructed in 1906-1907 on the Clark Fork River immediately below the confluence with the Blackfoot River for the purpose of producing hydroelectric power. Significant levels of arsenic, lead, zinc, cadmium, and other hazardous substances have been found in the approximately six million cubic yards (4.6 million m^3) of sediments that have accumulated behind the dam (U.S. EPA and MDHES 1990). The reservoir was designated an NPL site in 1983.

Multiple, and at times continuous, releases of hazardous substances to both surface and groundwaters have occurred repeatedly through river action, resuspension and transport of sediments, and exchange with the groundwater aquifer.

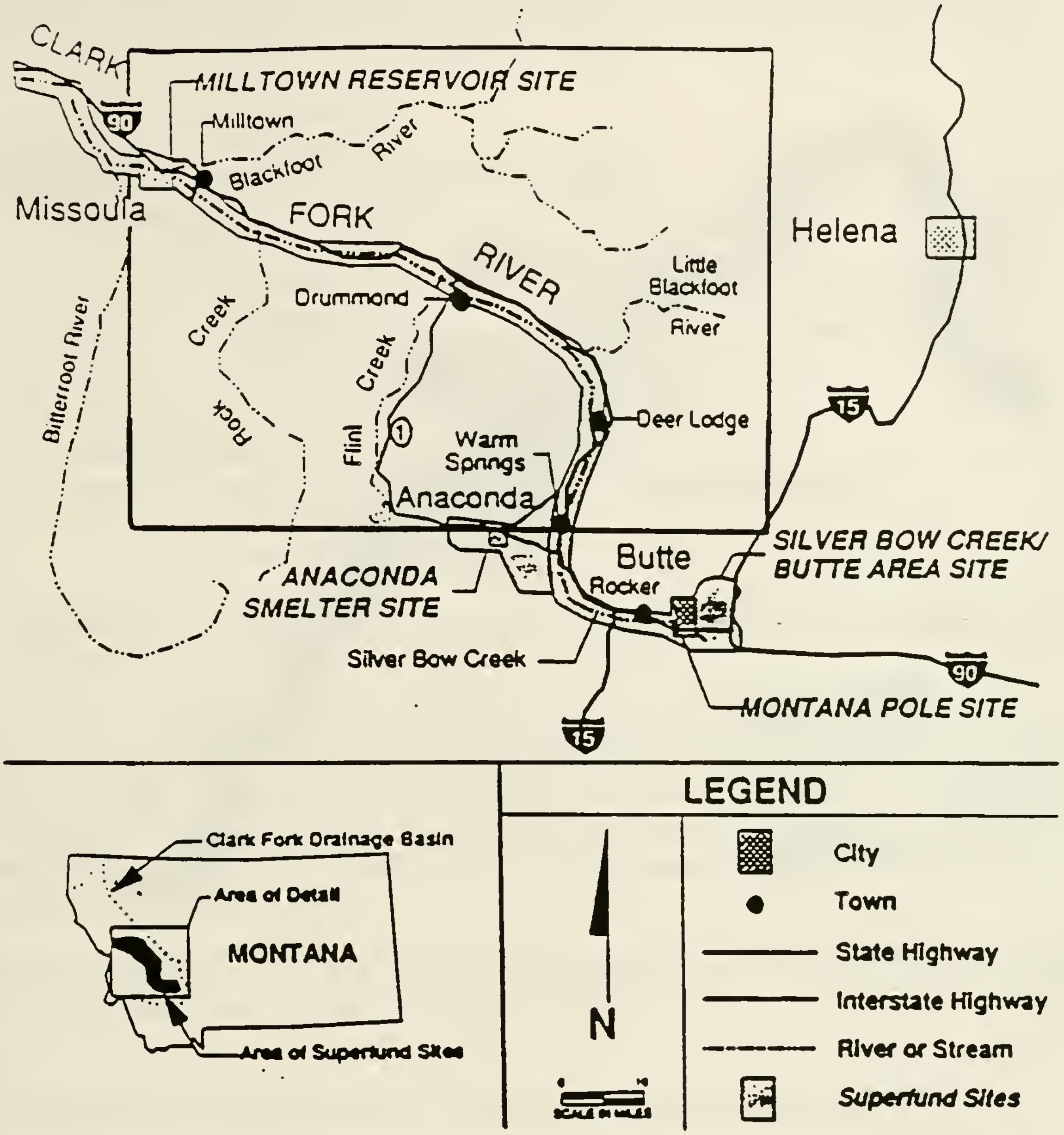

Figure 4. Clark Fork River Operable Unit: Milltown Reservoir Site (U.S. EPA and MDHES 1990).

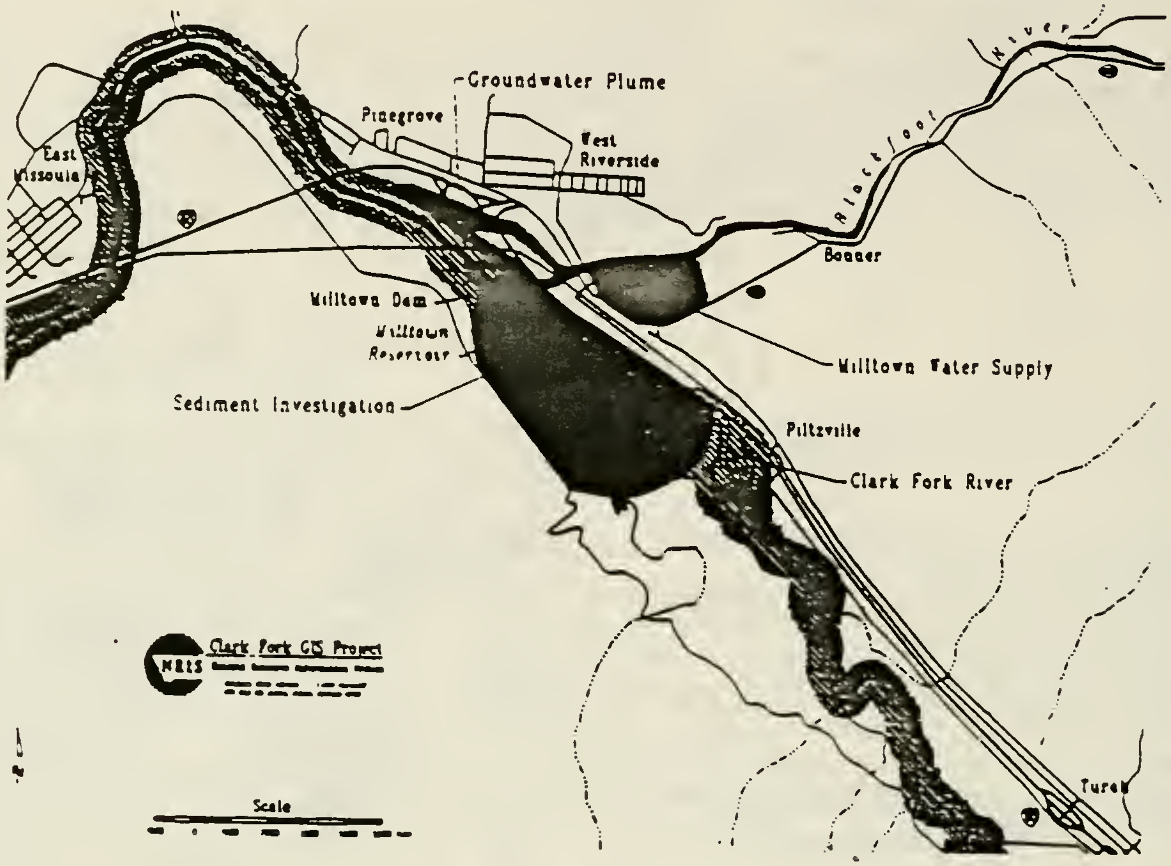

Figure 5. Milltown Reservoir Site (U.S. EPA and MDHES 1990).

2.4 HAZARDOUS SUBSTANCES RELEASED

Hazardous substances (as given in the List of Hazardous Substances and Reportable Quantities, Table 302.4 at 40 CFR 302.4) identified thus far as having been released from the Clark Fork sites include, but are not limited to:

- Arsenic and compounds,
- Beryllium and compounds,
- Cadmium and compounds,
- Copper and compounds,
- Creosote,
- Lead and compounds,
- Mercury and compounds,
- Pentachlorophenol (PCP),
- Polycyclic aromatic hydrocarbons (PAH),
- Selenium and compounds,
- Silver and compounds,
- Volatile organics (ethylbenzene, xylenes, benzene, toluene), and
- Zinc and compounds.

2.5 ADDITIONAL HAZARDOUS SUBSTANCES POTENTIALLY RELEASED FROM THE SITES

A number of additional organic compounds have been identified as having potentially been released at the Montana Pole site, including tetrachlorophenols, higher chlorophenols, dioxins/furans, and complex phenols (Camp Dresser & McKee 1989a). Principal toxic components of creosote include the polycyclic aromatic hydrocarbons phenanthrene, anthracene, naphthalene, fluoranthrene, pyrene, chrysene, fluorene, and acenaphthene (Camp Dresser & McKee 1989a).

Petroleum, a hazardous or deleterious substance pursuant to the Montana CECRA statute, has also potentially been released at the Montana Pole site.

2.6 RELEVANT OPERATIONS OCCURRING AT OR NEAR THE SITES

Relevant operations occurring at or near the sites include various public works facilities, agricultural operations, and limited industrial operations. Additional operations relevant to the State of Montana's estimation of natural resource damages in the Clark Fork Basin are actions related to remedies planned and/or already implemented at the numerous operable units contained in the four NPL sites (Table 1). These actions include full-scale remedial investigation/feasibility studies (RI/FS), Time-Critical Response Actions (actions completed within a reasonably short period of time following discovery of an imminent threat to human health and/or the environment), and Expedited Response Actions (non-time-critical responses to significant threats).

2.7 POTENTIALLY RESPONSIBLE PARTIES

The U.S. EPA and the State of Montana have identified the Atlantic Richfield Company (ARCO) as the primary Potentially Responsible Party at all four of the Clark Fork NPL sites (U.S. EPA and MDHES 1990).

2.8 DAMAGES EXCLUDED FROM LIABILITY

The State of Montana is not aware of any damages which would be excluded from liability under CERCLA. Specifically, none of the following conditions apply:

(a) The damages resulting from the releases were specifically identified as an irreversible and irretrievable commitment of natural resources in an environmental impact statement or other comparable environmental analysis, that the decision to grant the permit or license authorizes such commitment of natural resources, and that the facility or project was otherwise operating within the terms of its permit or license; or

(b) The damages and the release of a hazardous substance from which such damages resulted have occurred wholly before enactment of CERCLA; or

(c) The damages resulted from the application of a pesticide product registered under the Federal Insecticide, Fungicide, and Rodenticide Act, 7 U.S.C. §§ 135-135k; or

(d) The damages resulted from any other federally permitted release, as defined in §§ 101(10) of CERCLA.

3.0 PREASSESSMENT SCREEN -- PRELIMINARY IDENTIFICATION OF RESOURCES AT RISK (§11.25)

3.1 PATHWAY IDENTIFICATION

Exposure pathways linking natural resources to hazardous substances released in the Clark Fork Basin and affected areas include:

(a) *Direct contact by natural resources* with hazardous substances concentrated in waste rock, mill tailings, furnace slag and flue dust (Moore and Luoma 1990). For example, Moore and Luoma (1990) estimate that the more than 200 million cubic meters (261 million yd^3) of tailings in the Clark Fork Basin contain approximately 9,000 tonnes (9,900 tons) of arsenic, 200 tonnes (220 tons) of cadmium, 90,000 tonnes (99,000 tons) of copper, 20,000 tonnes (22,000 tons) of lead, 200 tonnes (220 tons) of silver, and 50,000 tonnes (55,000 tons) of zinc. Direct contact may occur for both biotic resources (e.g., wildlife via dermal, inhalation, and ingestion) and abiotic resources (e.g., surface and groundwater via contact with hazardous substances).

(b) *Exposure to surface waters* contaminated through releases of hazardous substances. For example, concentrations of copper, zinc, lead, and cadmium regularly exceed U.S. EPA water quality criteria for freshwater aquatic life (Ingman and Kerr 1990). Both aquatic and terrestrial biota may be exposed to hazardous substances via this pathway through ingestion and dermal/opercular absorption.

(c) *Exposure to contaminated groundwater.* Groundwater contaminated through leaching of metals and organics released to the surface operates as a critical exposure pathway through interchange processes with surface waters. For example, Camp Dresser and McKee (1990a) has estimated that as much as 80-90% of the metals loading to Silver Bow Creek during base flow is associated with inputs of contaminated groundwater.

(d) *Aerial transport and deposition.* Soils contaminated by aerial deposition of hazardous substances visibly affect vegetation over an area of at least 300 km^2 (116 mi^2) surrounding the Anaconda Smelter site (Johnson and Schmidt 1988). After soil sampling performed in the area of the smelter, Tetra Tech (1987) concluded that:

- Concentrations of heavy metals and arsenic decrease with increasing distance from the smelter.
- Soil contamination is most pronounced in the prevailing wind directions (northeast and southwest).

Aerial deposition can result in injuries to both abiotic and biotic natural resources.

(e) *Movement in aquatic and terrestrial food chains.* Food chain exposures occur when prey organisms accumulate hazardous substances in their tissues. Predators are subsequently exposed to these pollutants when they consume their prey. For example, Beyer (1990) cites numerous studies which document the uptake and subsequent terrestrial food-chain movement of the hazardous substances cadmium, copper, lead, and zinc. Phillips and Buhler (1978) documented the importance of dietary exposure routes of mercury uptake in rainbow trout.

Critical food chain pathways in the Clark Fork Basin may include:

- Contaminant uptake by aquatic invertebrates which serve as a source of food for fish and birds.
- Contaminant uptake by fish which serve as prey for birds (e.g., bald eagles, herons) and furbearing mammals (e.g., otter, mink).
- Contaminant uptake by aquatic vegetation which serves as forage for aquatic herbivores (e.g., muskrat).
- Contaminant uptake by terrestrial vegetation which serves as forage for upland bird species (e.g., grouse) and mammalian herbivores (e.g., deer, elk).

(f) *Exposure via particulate movement.* Particulate movement, including resuspension and transport of contaminated sediments, streambanks, and floodplain sediments is a critical dispersion pathway in the Clark Fork Basin. River transport has led to detectable enrichment of hazardous substances hundreds of miles downstream from original sources in Butte (Andrews 1987; in Johnson and Schmidt 1988; Moore and Luoma 1990). Average concentrations of copper and arsenic in floodplain sediments in the Clark Fork as far downstream as Drummond (approximately 60 miles (97 km) from Butte) are several orders of magnitude greater than at uncontaminated tributaries (Johnson and Schmidt 1988).

3.2 EXPOSED AREAS

This section presents preliminary estimates of exposed areas based on a review of readily available information. This section is not a comprehensive quantification of all exposed areas.

3.2.1 Primary Depositional Areas

Preliminary estimates of areas exposed to hazardous substances via **direct** deposition include:

(a) Over 4,000 acres (1,620 ha) of tailings ponds (including Opportunity and Anaconda ponds) and slag in the Anaconda area (Johnson and Schmidt 1988).

(b) Approximately 1.7 million cubic yards (1.3 million m^3) of slag at the Old Works operable unit at the Anaconda site (CH_2M Hill 1984).

(c) 250,000 cubic yards (191,250 m^3) of flue dust in the Anaconda area (CH_2M Hill 1984).

(d) 600,000 cubic yards (229,500 m^3) of tailings covering 67 acres (16.2 ha) along Silver Bow Creek in Butte (CH_2M Hill, Inc. and Chen-Northern, Inc. 1989).

(e) 950,000 square feet (88,300 m^3) of contaminated soil on the Montana Pole site (Camp Dresser & McKee 1989a).

(f) The 750 acre (304 ha) Yankee Doodle Tailings ponds in the Butte Area of the Silver Bow Creek site (Camp Dresser & McKee 1990a).

(g) Leach pads and waste dumps north and northeast of the Berkeley Pit covering 1,400 acres (567 ha) (Camp Dresser & McKee 1990a).

(h) Numerous other tailings, waste rock, and slag deposits in the Butte and Anaconda areas.

3.2.2 Areas Exposed through Pathways

Preliminary estimates of exposed areas via **pathways** in the Clark Fork Basin include:

(a) Surface waters including, but not limited to: Silver Bow Creek, the Clark Fork River, Warm Springs Creek, Mill Creek, Willow Creek, and the Mill-Willow Bypass.

(b) Surface and groundwaters associated with the Berkeley Pit.

(c) Bank, bed, and floodplain sediments of the surface waters described above.

(d) Riparian vegetation associated with the surface waters described above.

(e) 8.4 million cubic feet (238,000 m^3) of alluvial groundwater on the Montana Pole site (Camp Dresser & McKee 1989a).

(e) At least 300 km^2 (116 mi^2) of contaminated soils and contaminated vegetation surrounding the Anaconda site (Johnson and Schmidt 1988), extending as far west as the Continental Divide.

(f) Surface water, bank and bed sediments, and vegetation of Warm Springs Ponds.

(g) Groundwater in the Butte Area, including areas that recharge to Silver Bow Creek.

(h) Groundwater at the Rocker operable unit.

(i) Groundwater at the Anaconda site, extending to and underlying the Clark Fork River.

(j) Groundwater in Milltown.

3.2.3 Areas of Indirect Effect

Although currently unquantified, areas of indirect exposure to hazardous substances may have occurred (and continue to occur) through food-chain and related biological mechanisms. Specific areas of concern may include, but not necessarily be limited to:

(a) The Warm Springs Ponds habitat (movement of hazardous substances into upland areas via food chain effects).

(b) Upland wildlife habitat above Anaconda (uptake of hazardous substances by plants via atmospheric deposition and soil uptake mechanisms, with subsequent movement of hazardous substances into mammals and upland birds via ingestion of contaminated soils and vegetation).

3.3 ESTIMATES OF CONCENTRATIONS

This section presents examples of concentrations of hazardous substances in the Clark Fork Basin and affected areas. This section is not a comprehensive review; rather, examples are drawn from a rapid review of the readily available literature. Concentrations of hazardous substances have been measured at a number of sites and operable units as part of the RI/FS process. Examples of these measurements are summarized in Tables 2 and 3, and, in limited fashion, the text below.

To place the concentration data in appropriate perspective, Alloway (1990) estimates normal, background soil concentrations to range from 0.1-40 ppm for arsenic, 0.01-2.0 ppm for cadmium, 2-250 ppm for copper, 2-300 ppm for lead, and 1-900 ppm for zinc. With respect to sediment samples, Camp Dresser & McKee (1989b) suggest background concentrations as being approximately ~0 ppm for arsenic, <1 ppm for cadmium, ~20 ppm for copper, 20 ppm for lead, and ~0 ppm for zinc. Finally, water concentrations can be compared to U.S. EPA's ambient water quality criteria for the protection of aquatic life (Table 4).

Table 2. Representative Surficial Concentrations of Hazardous Substances at Clark Fork NPL Sites

Toxicant Concentration (in ppm, unless otherwise noted) Note: µg/l = ppb								
Site	Area (Medium)	As	Cd	Cu	Fe	Pb	Zn	Reference
Silver Bow Creek	Colorado Tailings -							Duaime et al. 1987 (in Johnson & Schmidt 1988)
	Center Field (Tailings)			6,775(max)		1,383(max)		
				1,370($\bar{x}$)		667($\bar{x}$)		
	West Field (Tailings)			8,965(max)		942(max)		
				3,055($\bar{x}$)		615($\bar{x}$)		
	East Field (Tailings)			4,059(max)		1,196(max)		
				1,390($\bar{x}$)		765($\bar{x}$)		
Silver Bow Creek	Colorado Tailings-							Thornell 1985 (in Johnson & Schmidt 1988)
	Tailings (Tailings)	2,960(max)		6,730(max)		2,740(max)	8,230(max)	
		742($\bar{x}$)		3,058($\bar{x}$)		1,264($\bar{x}$)	4,945($\bar{x}$)	
	Peat (Soil)	1,550(max)		14,300(max)		14,900(max)	23,500(max)	
		821($\bar{x}$)		6,022($\bar{x}$)		9,933($\bar{x}$)	17,333($\bar{x}$)	
Silver Bow Creek	Silver Bow Creek							MultiTech 1987b (in Johnson & Schmidt 1988)
	Streamside Tailings (Tailings)	399	13.4	2,350		989	3,070	
Silver Bow Creek	Silver Bow Creek	0.02	0.034	1.21	6.00	0.023	8.8	CH$_2$M Hill 1989
	in Butte, MT (Water)	0.18	0.117	3.50	18.7	0.65	19.2	

Table 2 (con't). Representative Surficial Concentrations of Hazardous Substances at Clark Fork NPL Sites

Toxicant Concentration (in ppm, unless otherwise noted) Note: µg/l = ppb								
Site	Area (Medium)	As	Cd	Cu	Fe	Pb	Zn	Reference
Silver Bow Creek	Warm Springs Ponds (Water)	0.064	0.010	0.436	1.93	0.026	1.22	MultiTech 1987c
Silver Bow Creek	Warm Springs Pond #2 (Sediments)	294	103	3,940	71,000	542	12,100	MultiTech 1987c
	Warm Springs Pond #3 (Sediments)	422	193	5,170	95,300	183	32,300	MultiTech 1987c
Silver Bow Creek	Silver Bow Creek (Tailings) (maximum concentrations)	4,730		13,700		7,860	14,100	PTI 1989
Silver Bow Creek	Silver Bow Creek (Water)			2,200 µg/l(max)			3,740 µg/l(max)	Phillips & Spoon 1990
				254 µg/l($\bar{x}$)			605 µg/l($\bar{x}$)	
Silver Bow Creek	Butte (Water)	17 µg/l(max)		390 µg/l (max)			937 µg/l(max)	Ingman & Kerr 1990
		10 µg/l($\bar{x}$)		238 µg/l ($\bar{x}$)			694 µg/l($\bar{x}$)	
	Below Colorado Tailings (Water)	20 µg/l(max)		410 µg/l(max)			1,420 µg/l(max)	
		11 µg/l($\bar{x}$)		241 µg/l($\bar{x}$)			896 µg/l($\bar{x}$)	
	Ramsay (Water)	33 µg/l(max)		780 µg/l(max)			2,150 µg/l (max)	
		15 µg/l($\bar{x}$)		228 µg/l($\bar{x}$)			771 µg/l($\bar{x}$)	
Anaconda Smelter	Old Works							Tetra Tech 1987
	- black slag (Slag)	80 (max)						

Table 2 (con't). Representative Surficial Concentrations of Hazardous Substances at Clark Fork NPL Sites

Toxicant Concentration (in ppm, unless otherwise noted) Note: $\mu g/l$ = ppb								
Site	Area (Medium)	As	Cd	Cu	Fe	Pb	Zn	Reference
	- tailings (Tailings)	1,840						Tetra Tech (1987)
	- heap-roast slag (Slag)	1,070(max)						
	- flue material (Flue Dust)	10,400(max)						
	Soil Samples							
	- Opportunity (Soil)	370	5.2	583		111	197	
	- Valley (Soil)	430	10.2	1,679		146	608	
	- Inversion (Soil)	157	6.6	350		95	295	
	- Crackerville (Soil)	1,660	62	2,330		1,000	1,190	
Milltown Reservoir	Clark Fork River							Ray 1983 (in Johnson & Schmidt 1988)
	- Rocker (Sediments)	164	10.0	1,102				
	- Racetrack (Sediments)	402	11.6	2,375				
	- Garrison (Sediments)	629	5.0	1,587				
	- Drummond (Sediments)	578	12.9	4,155				
Milltown Reservoir	Clark Fork River							Moore 1985
	- water samples ($\bar{x}$) (Water)	58	6.3	449		68	1,767	

Table 2 (con't). Representative Surficial Concentrations of Hazardous Substances at Clark Fork NPL Sites

Toxicant Concentration (in ppm, unless otherwise noted) Note: μg/l = ppb								
Site	Area (Medium)	As	Cd	Cu	Fe	Pb	Zn	Reference
	- soil samples ($\bar{x}$) (Soil)	320	14.9	2,182		262	4,045	
Milltown Reservoir	Clark Fork River (Water)			220 μg/l(max)			284 μg/l(max)	Phillips & Spoon 1990
	- below Warm Springs (Water)			39 μg/l($\bar{x}$)			52 μg/l($\bar{x}$)	
Milltown Reservoir	Clark Fork River							Johnson & Schmidt 1988
	- Deer Lodge (Water)	130 μg/l(max)		630 μg/l(max)			770 μg/l(max)	
		17 μg/l (median)		59 μg/l (median)			80 μg/l (median)	
	- Turah Bridge (Water)						1,100 μg/l(max)	
Milltown Reservoir	Clark Fork River							Ingman & Kerr 1990
	- Dempsey (Water)	26 μg/l(max)		80 μg/l(max)			106 μg/l(max)	
		14 μg/l($\bar{x}$)		19 μg/l($\bar{x}$)			35 μg/l($\bar{x}$)	
	- Deer Lodge (Water)	22 μg/l(max)		50 μg/l(max)			73 μg/l(max)	
		13 μg/l($\bar{x}$)		22 μg/l($\bar{x}$)			38 μg/l($\bar{x}$)	

Table 2 (con't). Representative Surficial Concentrations of Hazardous Substances at Clark Fork NPL Sites

Site	Area (Medium)	Diesel	Oil/Grease	PCP	Fluorine	Benzo(a) Pyrene	Arsenic	Reference
Montana Pole	Silver Bow Creek (Water)	14.5		895 μg/l				Camp Dresser and Mckee 1989a
	Silver Bow Creek Downstream (Water)		1.1	19 μg/l				
	On-Site Soil (Soil)			4,000 (max)				
	Facility Yards (Soil)			3,500 (max)				
				1,060 ($\bar{x}$)				
Montana Pole	Outside Fenced Area (Soil)			1,026 μg/kg($\bar{x}$)				Camp Dresser and McKee 1990b
	Inside Fenced Area (Soil)			42,863 μg/kg($\bar{x}$)				
	Groundwater (Groundwater)			299 μg/l($\bar{x}$)	18.4 μg/l($\bar{x}$)	0.08 μg/l($\bar{x}$)	12.9 μg/l($\bar{x}$)	
	Silver Bow Creek (Water)			6.3 μg/l($\bar{x}$)	0.112 μg/l($\bar{x}$)		13.8 μg/l($\bar{x}$)	

Table 3. Representative Concentrations of Hazardous Substances in Groundwater at Clark Fork NPL Sites

Toxicant Concentration (in ppb = $\mu g/l$)								
Site	Area	As	Cd	Cu	Fe	Pb	Zn	Reference
Silver Bow Creek	Berkeley Pit							Camp Dresser and McKee 1988 (in Johnson and Schmidt 1988)
	-Depth 216 ft. (65.8m)	1,290	1,850	213,000		343	500,000	
	-Depth 426 ft. (129.8m)	1,380	1,860	209,000		576	505,000	
Silver Bow Creek	Colorado Tailings	140	520	54,100	224,700		159,000	Duaime *et al.* 1985
Silver Bow Creek	Near Warm Springs Ponds	244 (dissolved)		38 (dissolved)	119,000 (dissolved)	25 (dissolved)	400 (dissolved)	MultiTech 1987c
Anaconda Smelter				8 6			78 15	Tetra Tech 1986a
	Opportunity Ponds	24		37			166	Tetra Tech 1986b (in Johnson and Schmidt 1988)
Milltown Reservoir	Wells along Clark Fork River	170	14 11					CH_2M Hill et al. 1991
	Wells at Milltown Dam	102	7	180		80	1,570	Montana Power Co. 1987 (in Johnson and Schmidt 1988)
Montana Pole				50,000			100,000	Camp Dresser and McKee 1990b

Table 3 (con't). Representative Concentrations of Hazardous Substances in Groundwater at Clark Fork NPL Sites

Toxicant Concentration (in ppb = $\mu g/l$)								
Site	Area	PCP	Acenaphthene	Total Xylenes	Toluene	Benzene	Ethyl-Benzene	Reference
Montana Pole		1,100,000 880,000	2,480,000	540	57	17	16	Camp Dresser and McKee 1990b

Table 4
Water Quality Parameters of Four Heavy Metals for the Protection of Freshwater Aquatic Life

Metal	Hardness (mg/l=ppm as $CACO_3$	Acute Tox[1] (µg/l=ppb)	Chronic Tox.[2] (µg/l=ppb)	Source
Cadmium	100	3.9	1.1	U.S. EPA
	200	8.6	2.0	1985
Copper	100	18	12	U.S. EPA
	200	34	21	1985
Lead	100	83	3.2	U.S. EPA
	200	200	7.7	1985
Zinc	100	120	110	U.S. EPA
	200	210	190	1987

[1] Acute toxicity is defined as a one-hour average concentration that occurs not more than once in a three-year period.

[2] Chronic toxicity is a four-day average concentration that occurs not more than once in a three-year period.

3.3.1 Silver Bow Creek/Butte Area Sites

Tailings

Maximum copper concentrations in tailings areas have been found to range from 4,059 ppm to 14,300 ppm, with mean concentrations ranging from 1,390 ppm to 6,022 ppm (Duaime *et al.* 1987; Thornell 1985; in Johnson and Schmidt 1988). Similarly, elevated concentrations of other hazardous substances, including lead (942-14,900 ppm), arsenic (1,550-2,960 ppm), and zinc (8,230 - 23,500 ppm) have been documented (Duaime *et al.* 1987; Thornell 1985; in Johnson and Schmidt 1988).

Soil

Soil samples in the Butte Area have also shown elevated metals concentrations for arsenic[3] (399 ppm), cadmium (13.4 ppm), copper (2,350 ppm), lead (989 ppm), and zinc (3,070 ppm) (Multitech 1987b; in Johnson and Schmidt 1988).

Surface Water

Surface water contamination with hazardous substances has been documented as well. For example, Ingman and Kerr (1990) measured elevated concentrations in Silver Bow Creek of copper (390-780 ppb), zinc (937-2,150 ppb), and arsenic (17-33 ppb).

Groundwater

Elevated concentrations of hazardous substances in groundwater have also been documented. For example, Duaime *et al.* (1985) measured zinc concentrations of 159,000 ppb and copper concentrations of 54,100 ppb in groundwater underlying the Colorado tailings. Johnson and Schmidt (1988) report groundwater concentrations of 500,000 ppb zinc and 213,000 ppb copper in the Berkeley Pit.

3.3.2 Anaconda Sites

Tailings/Slag

Arsenic concentrations in slag and tailings in the Old Works Operable Unit have been found to range from 54-1,840 ppm (Tetra Tech 1987).

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[3] Values are average concentrations from samples taken between Butte and Warm Springs Ponds.

Soil

Soil concentrations have been found to range from 157-1,660 ppm in the Anaconda Valley (Tetra Tech 1987). Elevated concentrations of cadmium (5-62 ppm), lead (95-1,000 ppm), copper (350-2,330 ppm), and zinc (197-1,190 ppm) have also been documented in Anaconda Valley soils (Tetra Tech 1987).

Groundwater

MultiTech (1987c) found elevated arsenic concentrations in groundwater from wells located immediately downstream of the Opportunity Ponds, and downgradient of the Warm Springs Ponds (see Table 3). Copper and iron concentrations were also elevated. Tetra Tech (1986b; in Johnson & Schmidt 1988) measured 24 ppb arsenic, 37 ppb copper, and 166 ppb zinc in the groundwater plume below Opportunity Ponds. The contaminant plume extends at least one half mile downstream from the Warm Springs Ponds (Johnson and Schmidt 1988).

3.3.3 Milltown Sites

Surface Water

Surface water samples taken from the Clark Fork River show elevated concentrations of copper (59-630 ppb), zinc (73-770 ppb), and arsenic (17-130 ppb) (Ingman and Kerr 1990; Johnson and Schmidt 1988).

Sediment

Sediment samples taken from the Milltown Reservoir have shown elevated concentrations of arsenic (58-320 ppm), copper (449-2,182 ppm), zinc (1,767-4,045 ppm), lead (68-262 ppm), and cadmium (6-15 ppm) (Moore 1985).

Groundwater

Samples collected from monitoring wells in Milltown have shown elevated levels of hazardous substances (Table 3), and Woessner *et al.* (1984) concluded that the 120 million cubic feet (3.4 million m^3) of metal laden sediments in the Milltown Reservoir were a likely source of contamination to the alluvial groundwater system.

3.3.4 Montana Pole Site

Surface Water

At the Montana Pole site, surface water concentrations of pentachlorophenol (PCP) have ranged between 6.3 ppb (Camp Dresser & McKee 1990b) and 895 ppb (Camp Dresser & McKee 1989a). Measurable quantities of arsenic (13.8 ppb), oil & grease (1.1 ppm) and diesel (14.5 ppm) have also been found in Silver Bow Creek at or near the site (Camp Dresser & McKee 1989a, 1990b).

Soil

Soil concentrations of PCP at the site range from 1,026 to 42,863 ppb (Camp Dresser & McKee 1989a, 1990b).

Groundwater

Concentrations of hazardous substances in groundwater at the site range from 880,000 to 1,100,000 ppb for PCP (Table 3). Other groundwater concentrations of hazardous substances include almost 2,500,000 million ppb acenaphthene, 540 ppb total xylenes, 57 ppb toluene, 17 ppb benzene, and 16 ppb ethylbenzene, as well as 50,000 ppb copper, 100,000 ppb zinc, and 12.9 ppb arsenic (Camp Dresser & McKee 1990b).

3.3.5 Biological Samples

Significant concentrations of toxic elements have also been found in biological samples -- particularly aquatic organisms (Table 5). For example, Shambaugh (1983) reported copper concentrations as high as 1,673 ppm and 1,877 ppm in duckweed and periphyton, respectively, in samples taken from Warm Springs Ponds. Shambaugh also reports elevated concentrations of arsenic and cadmium in cattails, willows, *Daphnia* spp., zooplankton, and leeches.

Fish tissues have displayed elevated concentrations of metals for samples taken from the Clark Fork River. For example, Phillips and Spoon (1990) report elevated concentrations of copper (1,000-1,663 ppm) and zinc (120-725 ppm) in gill and liver tissues of brown trout. Van Meter (1974) reported elevated liver concentrations of copper (11,400 ppm), cadmium (690 ppm), lead (750 ppm), and zinc (38,000 ppm) in trout taken from the Upper Clark Fork River.

Table 5. Representative Residues of Hazardous Substances in Clark Fork River Biota

Approx. Location	Organism	Toxicant (in ppm, unless otherwise noted)					Reference
		As	Cd	Cu	Pb	Zn	
Warm Springs Pond #3							Shambaugh 1983
	Periphyton	86	50	1,877			
	Duckweed	94	29	1,673			
	Cattail		3.2	33			
	Willow	1.5	3.5	2.5			
	Daphnia spp.	11	20	190			
	Zooplankton	4.4	9.9	134			
	Leech	38	6.1	295			
Warm Springs Pond #2							
	Periphyton	59	17	316			
	Trout liver	0.99	1.6	908			
Clark Fork River	Brown Trout						
	- Gill tissue in distilled water		1.5	50			Phillips 1985

Table 5 (con't). Representative Residues of Hazardous Substances in Clark Fork River Biota

Approx. Location	Organism	Toxicant (in ppm, unless otherwise noted)					Reference
		As	Cd	Cu	Pb	Zn	
Clark Fork River	Brown Trout						
- Warm Springs	- liver		~2	1,663		~140	Phillips & Spoon 1990
	- kidney		~5.5	~11		~250	
	- gill tissue		~1.0	~17		~700	
- Deer Lodge	Brown Trout						
	- liver		~1.0	~1,000		~120	
	- kidney		~2.9	~7		~250	
	- gill tissue		~0.7	~10		~725	
Clark Fork River							Axtmann et al. 1990
- Above Little Blackfoot River	Hydropsyche spp.		2.8	204	12.8		
	Claasenia sabulosa		~1.8	~60	~2.5		
- Between Flint Creek & Rock Creek	Hydropsyche spp.		2.2	72	8.1		

3.4 POTENTIALLY AFFECTED RESOURCES

Natural resources for which the State of Montana is Trustee and which have been affected or potentially affected by releases of hazardous substances include, but are not limited to, the following:

(a) Surface water, including the Clark Fork River, Silver Bow Creek, Warm Springs Creek, Mill Creek, Willow Creek, and Warm Springs Ponds.

(b) Sediments (including both bank, bed, and floodplain sediments) associated with surface waters described above.

(c) Groundwater, including aquifers underlying Butte, Anaconda, and Milltown.

(d) Soils, including lowland and floodplain soils, as well as significant upland areas affected by aerial deposition.

(e) Riparian wetlands, including Warm Springs Ponds.

(f) Resident fish of many species, including trout of various species.

(g) Aquatic invertebrates of many species.

(h) Vegetation, including upland and riparian vegetation.

(i) Wildlife, including small mammals and big game species, birds, invertebrates, amphibians, and other animals.

(j) Air.

3.5 PRELIMINARY ESTIMATE OF AFFECTED SERVICES

Services provided or potentially provided by the resources identified in Section 3.4 include:

(a) Water for drinking and other domestic uses.

(b) Water for irrigation of crops and livestock.

(c) Primary and secondary contact recreation, including swimming, boating, and other activities.

(d) Consumptive and non-consumptive outdoor recreation, including fishing, hunting, trapping, and wildlife viewing and photography.

(e) Habitat for fish and wildlife, including food, shelter, breeding and rearing areas, and other factors essential to long-term survival.

(f) Air for breathing, visibility, and aesthetics.

(g) Use, option and bequest values related to all of the above services.

(h) Non-use values, including existence values, related to all of the above services.

4.0 PREASSESSMENT SCREEN -- DETERMINATION CRITERIA (§11.23(e))

Based on the criteria identified below, the State of Montana has determined that a Natural Resource Damage Assessment shall be carried out for releases of hazardous substances into the environment of the Clark Fork Basin.

4.1 A RELEASE OF HAZARDOUS SUBSTANCES HAS OCCURRED

Releases of hazardous substances from sources for which ARCO is a potentially responsible party have been well documented. Hazardous substances include, but may not be limited to, arsenic, beryllium, cadmium, copper, creosote, lead, mercury, PAH, PCP, selenium, silver, volatile organic compounds, and zinc. The U.S. EPA and State of Montana have documented such releases in numerous RI/FS reports. The U.S. EPA has designated four distinct National Priority List Sites -- with numerous operable units -- in the Clark Fork Basin.

Hazardous substances have been released to the Basin through both primary point sources (e.g., smelter stacks, tailings deposits), and through secondary pathways (e.g., uptake and deposition through river action, groundwater movement).

4.2 NATURAL RESOURCES FOR WHICH THE STATE OF MONTANA IS TRUSTEE HAVE BEEN ADVERSELY AFFECTED BY THE RELEASE

Natural resources for which the State of Montana is Trustee and which have been affected or potentially affected by releases of hazardous substances include, but are not limited to the those resources identified in Section 3.4.

4.3 THE QUANTITY AND CONCENTRATION OF THE RELEASED HAZARDOUS SUBSTANCES ARE SUFFICIENT TO CAUSE INJURY

4.3.1 Surface Water

Confirmation of injury to surface waters (as defined by the Department of the Interior at 43 CFR Section 11.62) may occur when concentrations of hazardous substances exceed either drinking water standards or water quality criteria established for the protection of aquatic life.

The evidence of heavy metals at toxic levels in the Clark Fork Basin has been documented numerous times over the past twenty years. The U.S. EPA has set water quality criteria for the protection of freshwater aquatic life from heavy metals (see Table 4). Concentrations of hazardous substances, especially copper, cadmium, zinc, and lead, often exceed the U.S.

EPA standards in Silver Bow Creek, Warm Springs Ponds, and in the main stem of the Clark Fork as far downstream as Rock Creek (Ingman and Kerr 1990). In FY 1989, toxic levels of copper, zinc, lead, and cadmium were frequently exceeded (for hardness of 100 mg/L (ppm) as $CaCO_3$). In Silver Bow Creek, cadmium exceeded chronic toxicity levels over 75% of the time in FY 1989, while copper and zinc exceeded acute toxicity levels 100% of the time in FY 1988 and 1989 (Ingman and Kerr 1990).

When Silver Bow Creek enters Warm Springs Ponds, metals tend to settle out of suspension and are deposited into sediments in the Warm Springs Ponds complex; metals concentrations are often an order of magnitude lower below the ponds, yet the concentrations frequently exceed U.S. EPA standards (Ingman and Kerr 1990). In FY 1989, the concentrations of copper, zinc, lead, and cadmium exceeded chronic toxicity standards 29, 14, 14, and 13 percent of the time, respectively, at the Warm Springs Ponds discharge (Ingman and Kerr 1990). Downstream of Warm Springs, metals concentrations in FY 1988-1989 continued to exceed chronic toxicity standards for copper, lead, and zinc (Ingman and Kerr 1990).

During the period FY 1985-1987, the average annual concentrations of copper and zinc in Silver Bow Creek were ten to over 20 times the established threshold for chronic toxicity (for hardness of 100 mg/L (ppm) as $CaCO_3$) (Johnson and Schmidt 1988). The acute toxicity levels of copper, zinc, lead, and cadmium were exceeded in the Warm Springs Ponds discharge, and the chronic toxicity level of zinc and the acute toxicity level of copper were exceeded in the Mill-Willow Bypass (Ingman and Kerr 1990).

Earlier studies have also documented elevated heavy metals contamination in the Clark Fork Basin. Phillips (1985) found copper and zinc concentrations at Deer Lodge to be nine times and one and one half times the acute toxicity threshold, respectively (for hardness of 200 mg/L (ppm) as $CaCO_3$). During spring runoff, copper concentrations were up to ten times higher than the acute threshold (Montana DNR 1988). Heavy metal contamination in the upper Clark Fork Basin has been reported by numerous other sources as well (i.e., Casne *et al.* 1975; Montana DHES 1983).

4.3.2 Groundwater

Confirmation of injury to groundwater resources (43 CFR Section 11.62) may occur when concentrations of hazardous substances exceed Federal or State drinking water or surface water standards.

The Silver Bow Creek Remedial Investigation identified drinking water quality exceedences for arsenic, cadmium, copper, lead, and zinc in several of the monitoring wells sampled in the Upper Silver Bow Creek area. Six of the domestic wells sampled exceeded secondary drinking water standards for arsenic, cadmium, iron, and/or zinc; one of the wells exceeded primary drinking water standards for cadmium (MultiTech 1987a). MultiTech (1987a) determined that groundwater concentrations posed a possible health threat to human health, aquatic life, and the environment.

Groundwater samples taken near the Montana Pole NPL Site between December 1984 and July 1985 contained 10,000-160,000 ppb pentachlorophenol (PCP), while groundwater samples taken in August 1985 contained PCP concentrations from 25 ppb to 1,100,000 ppb (Camp Dresser & McKee 1990b). PCP concentrations up to 880,000 ppb, and acenaphthene concentrations up to 2,480,000 ppb were detected in groundwater during the period 1988-1990 (Camp Dresser & McKee 1990b). Xylenes (7.9-540 ppb), toluene (5.5-57 ppb), benzene (1.2-17 ppb) and ethylbenzene (1.7-16 ppb) were also detected at that time. Camp Dresser & McKee (1990b) measured groundwater concentrations of 50,000 ppb copper, and 100,000 ppb zinc.

CH_2M Hill (1991) sampled domestic wells suspected of having a high probability of degraded water quality due to proximity to tailings or contaminated floodplain sediments. They found that the primary drinking water standard for cadmium (10 ppb) was exceeded in a well six miles north of Deer Lodge (14 ppb), and that eleven wells between Deer Lodge and Bearmouth contained secondary exceedences for one or more of iron, manganese and sulfate. The U.S. Geological Survey (USGS) studied aquifers between Warm Springs and Milltown, sampling 50 wells. Of those, 42% (21 wells) contained at least one constituent value that equalled or exceeded either primary or secondary drinking water standards (Johnson and Schmidt 1988).

Arsenic contamination in wells has been documented as far downstream as Milltown (Woessner *et al.* 1984).

4.3.3 Aquatic Organisms

Injury to biological resources (43 CFR Section 11.62) may occur if releases of hazardous substances cause death, disease, behavioral abnormalities, physiological malfunctions, cancer, physical deformations, or genetic mutations.

The levels of copper, zinc, cadmium, and lead in the upper Clark Fork have been shown to be toxic to many species of fish. The high copper levels are lethal to rainbow trout (Anadu *et al.* 1989; Dixon and Sprague 1981; Laurén and McDonald 1986; Miller and Mackay 1980), as are the zinc levels (Bradley and Sprague 1985; Handy and Eddy 1990) and the lead levels (Davies *et al.* 1976). The high heavy metals content is also lethal to westslope cutthroat (Chakoumakos *et al.* 1979), brook trout (McKim and Benoit 1971), and brown bullhead (Biesinger and Christiensen 1972).

Fish kills in the Clark Fork River have occurred frequently. Averett (1961) reported numerous fish kills in the middle Clark Fork between 1958 and 1960. Between 1983 and 1988 there were at least six documented fish kills, some killing several thousand fish (Johnson and Schmidt 1988). Water quality of Silver Bow Creek is sufficiently contaminated because of releases of hazardous substances to preclude the establishment of self-reproducing fish populations.

Exposure to elevated copper concentrations can cause serious deterioration to fish health as well. These effects include damage to olfactory and taste organs, vision impairment, and inhibited acetylcholinesterase (AChE) activity in the brain, which may affect synaptic transmission (Baatrup 1991; Nemcsók and Hughes 1988). Copper affects fish blood chemistry, causing an increase in hematocrit, hemoglobin, and blood glucose while decreasing chloride cells and plasma protein (Biesinger and Christiensen 1972; Nemcsók and Hughes 1988). Other adverse effects of copper exposures include:

- Reduction in breathing efficiency (Benedetti *et al.* 1989; Laurén and McDonald 1986; Reid and McDonald 1988).
- Suppression of the humoral immune system (O'Neill 1981a).
- Decreased swimming speed (Waiwood and Beamish 1978).

Exposure to cadmium, lead, and zinc has also been shown to adversely affect fish health. Like copper, all three metals suppress the fish immune system (O'Neill 1981a,b; Thuvander 1989). Zinc adversely affects the nervous system and sensory organs (Baatrup 1991). High cadmium levels cause damage to gill epithelium, as well as inhibiting calcium flux across the gills, thus significantly decreasing respiratory efficiency (Reader and Morris 1988; Reid and McDonald 1988; Verbost *et al.* 1987; Verbost *et al.* 1989). Finally, Benoit (1976) found that brook trout respond to high cadmium levels with nervous disorders and hyperactivity.

4.3.4 Wildlife

The uptake of heavy metals by birds and mammals can cause impairment or destruction of biological functions and processes at the cell, organ, animal, or population level (Wren 1987). Signs and symptoms of heavy metal poisoning vary by animal species and are dependent on the metal, exposure route and duration, and rate of absorption/excretion. Table 6 provides examples of the mechanism of action and effect on mammals of selected hazardous substances released to the Clark Fork Basin. In waterfowl, ingested lead is known to cause reduced fecundity or mortality (Elder 1954; Bellrose 1951; Del Bono and Braca 1973; in Frederick 1976).

4.3.5 Vegetation and Soils

Stunted growth, chlorosis, necrosis, leaf epinasty and reddish brown discoloration are visible symptoms of severe metal phytotoxicity (Lepp 1981; Van Assche and Clijsters 1990; Woolhouse 1983). Plant uptake of non-essential trace elements and elevated levels of micronutrients may lead to reduced survival and reproductive success, or morphological deformation. Table 7 lists plant concentrations reported to cause a yield reduction in wheat and grass species and compares plant concentrations sampled in the Clark Fork River Basin. The following are examples of plant responses to heavy metals documented in the literature:

Table 6
Examples of Effects of Selected Hazardous Substances Found in the Clark Fork River Basin (Wren 1987)

Contaminant	Mechanism	Target System	Effects and Symptoms
Arsenic	Enzyme inhibition	Gastrointestinal, lungs	Abdominal pain, diarrhea, weakness, paralysis
Cadmium	Interferes with zinc containing enzymes; bioaccumulates	Kidney, liver, bone, reproductive system	Impaired kidney function, impaired reproduction, slow growth
Lead	Disrupts oxygen supply; impedes synthesis of red blood cells and hemoglobin; accumulates in liver, kidney	Central nervous system, gastrointestinal, circulatory	Anorexia, lethargy, muscle tremors, convulsions

Table 7. Plant Tissue Concentrations Reported for Clark Fork River Basin Vegetation Compared with Grass and Wheat Leaf Concentrations Known to Have Produced a 10% Biomass Decrease.

	Critical Levels Reported for Grass and Wheat[1]	Grass at Slickens Perimeter[2]	Smelter-till RI/FS Vegetation Samples (horsebrush)[3]	
			mean	range
Arsenic	2-16	4.29 4.04 7.06	99.9	14-239
Cadmium	10-43	--	5.1	0.7-14
Copper	14-30	--	467	46-1500
Zinc	108-224	--	432	57.6-1570

all concentrations in ppm

[1] MacNicol 1985

[2] Rice and Ray 1985

[3] PTI Environmental Services 1990

- Uptake of the ionic forms of lead and cadmium have been shown to inhibit photosynthesis by decreasing stomatal conductance, reducing photosynthetic pigments, inhibiting chloroplast activity, and by interfering with metabolic processes (Clijsters and Van Assche 1985; Mohanty and Mohanty 1988; Sheoran *et al.* 1990a,b).

- Lab studies involving cadmium additions to pea plants have shown that prolonged exposure to cadmium results in inhibition of photosynthesis and transpiration, and that certain growth stages are more sensitive to heavy metal contamination than others (Sheoran *et al.* 1990b).

- Cadmium and copper are each known to cause premature leaf abscission in plants (Vasquez *et al.* 1989); excessive plant concentrations of copper are also associated with reduced plant growth (Pahlsson 1989; Rhoads *et al.* 1989).

- Excessive uptake of zinc is known to cause water stress and wilting in plants, and increased permeability of root membranes which allows nutrients to leak out (Pahlsson 1989).

- Arsenic in several forms is used as an herbicide, insecticide, silvicide and soil sterilant (Taskey 1972). Arsenic toxicity can be manifested through both reduced growth, stem teratogeny, lack of finely branched roots, and leaf discoloration (Arnott 1965; Arnott and Leaf 1967; in Taskey 1972).

Examples of potential injuries to vegetation caused by releases of hazardous substances in the Clark Fork Basin include the State-owned Mt. Haggin Game Management Area and surrounding lands; upland vegetation has potentially been injured by the repeated re-release through pathways of hazardous substances released by the Washoe Smelter (Taskey 1972). Taskey (1972) concluded that the hazardous substances arsenic, copper, lead and zinc, have weakened or killed existing vegetation, and have contaminated soils to the extent that vegetation re-establishment and ecosystem recovery is significantly impaired.

4.4 DATA SUFFICIENT TO PURSUE AN ASSESSMENT ARE AVAILABLE OR LIKELY TO BE OBTAINED AT REASONABLE COST

Significant amounts of data relevant to conducting an assessment have been generated by the U.S. EPA and federal contractors, the State and its contractors, and ARCO and its contractors as part of the RI/FS process at the four NPL sites. Such data include information on contaminant concentrations, sources, and pathways. In addition, the various state agencies have collected data for many years on surface water and groundwater contaminant concentrations, soil, sediment, air concentrations, fish-tissue concentrations, fish populations, and other biological population and inventory data.

Researchers from the University of Montana, Montana State University, and the Montana School of Mines have also collected important and relevant data which could be applied to a complete assessment.

Finally, the cost of collecting additional data for the purposes of performing a damage assessment is expected to be substantially less than the anticipated damage amount determined in the assessment.

4.5 RESPONSE ACTIONS WILL NOT SUFFICIENTLY REMEDY THE INJURY TO NATURAL RESOURCES WITHOUT FURTHER ACTION

The limited number of remedies that have been implemented in the Clark Fork Basin have not restored the injured natural resources. Moreover, it is unlikely that the natural resources of the Basin will be restored for centuries to come, if at all. Therefore, there exist potential past, present, and unremediated future and residual future damages in the Clark Fork Basin and affected areas.

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